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RESEARCH ARTICLE

MEASUREMENT GAMMA RAY OF TRANSMISSION FACTORS OF VARIOUS CONSTRUCTION MATERIALS THAT PREPARED AS MIXED WITH BORAX AND KESTELEK BORON WASTE IN DIFFERENT PROPORTIONS

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ABSTRACT

Measurements have been made to identify modification of the γ-ray transmission factors of various construction materials according to percentage increasing concentration of borax and Kestelek boron waste by using a narrow-beam-geometry at 59.5 keV. Photons passed through different samples were detected with a very sensitive Si(Li) detector. We have made to investigate experimental results and these results discussed in this paper.

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INTRODUCTION

In today, states, universities, foundations, voluntary and professional promoters have worked for prevention of the harmful effects of radiation, recycling of waste and protection of vital water resources. The basic elements of quality of life that preservation of nature and environment, unlimited needs to respond of limited resources, sustainability, green energy, ecological balance and notions such as carbon footprint have been important. Therefore, these topics should be studied.

Boron has an atomic number of 5 and is located on the periodic table in group IIIA. Its quantum representation is $1s^2 2s^2 2p^1$. Boron is an element commonly found on earth. This element can found in soil, rock or water. In nature, boron is seen in the shape of boric acid, borate (i.e., salt of boric acid), or as a borosilicate mineral. Generally, boron content of soil has average 10-20 ppm but, this content has found high concentration in the west locality of USA and the region extending from the Mediterranean to Kazakhstan. Boron content of sea water has average 0.5-9.6 ppm, in the freshwater 0.01-1.5 ppm range. Deposits in the high concentration of boron, compound with oxygen bonded of boron have been found in arid, volcanic and the high regions of hydrothermal activity of Turkey and USA.

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Turkey has boron reserves above 800 million tonnes, which consist of about 70% of the total world boron reserves. Alone Turkey can respond to boron needs of world 250 years. The most significant boron ores in Turkey are colemanite, ulexite and tincalconite. Turkey has share raw boron exports above 95% of in the world with the amount of 900,000 tonnes exported. The Kestelek Boron Company has 160,000 tonnes/year production capacities. The Kestelek Boron Company can handle 90,000 tonnes gem in the year and in this facility has 30,000 tonnes waste in the year. A large amount of this waste isn't disregard. This waste is collect near area of facility, waste collection pools or discharged into lakes and rivers. But, these wastes have been cause some problems that storage cost depends on the boron content, environmental pollution and stocking of waste. Reclamation and consideration of boron wastes can be removed these problems. New products and application areas have emerged with removal of these problems. Boron is called oil of 20 century that construction-cement industry, glass fiber, wood protection, nuclear applications, metallurgy, automobile airbag, antifreeze, health, missile flight fuels, waste removal, boron solid fuel/fuel cells, energy production, heat storage, magnetic devices and optical fiber etc. area are used.

The interaction with matter of electromagnetic radiation for theoretical and experimental work has been an important issue. In recent years, the interactions with boron containing matter of electromagnetic radiation and construction materials have been observed by many researchers. (Elbeyli, 2004) has investigate the effects of BWs (borax wastes), which have high and low B_2O_3 content, on the physical and mechanical properties of Portland cement. Mass attenuation coefficients of various boron compounds (H_3BO_3; $Na_2B_4O_7$ and $B_3Al_2O_3$) and the trommel sieve waste (TSW) have been determined in the energy region 15.746–40.930 keV by (İçelli *et al.,* 2003). (Kurudirek *et al.,* 2010) have investigated chemical compositions of the construction materials using (WDXRFS). Additionally, TSW, some widely used construction samples (Portland cement, lime and pointing) and their admixtures with TSW have been determined in terms of (μ/ρ), (σ_t), (Z_{eff}) and (N_e) by using X-rays at 22.1, 25 keV and γ-rays at 88 keV photon energies. The apply γ-ray transmission (GRT), a non destructive technique, in the structural characterization of low-porosity ceramic samples. GRT technique is based on the attenuation that photons of an incident radiation beam undergo when passing through the material. With this technique the porosity of alumina (Al_2O_3) and boron carbide (B_4C) ceramic samples, have been determined at 59.6 keV by (Moreira *et al.,* 2013). In the present study, we measured the experimental transmission coefficient of samples that prepared as mixed with different ratio of borax and slime together with various construction material such as tile adhesive, clay, satin plaster, black cement (strength of daily pressure = 32.5; 42.5 and 52.5 MPa), grouting and fly ash by using energy dispersive X-ray fluorescence spectrometer (EDXRF) at 59.5 keV.

Theory

γ and X-ray transmission factors are used in a wide variety of industrial and medical applications. These factors of various samples can be determined. Such as construction materials, biological materials, crystals, polymers. Transmission ratios give information about structure of the material. Also, the important atomic parameters such as the mass attenuation coefficients (μ/ρ), molecular ($\sigma_{t,m}$), atomic ($\sigma_{t,a}$), electronic cross-sections (σ_e), effective atomic numbers (Z_{eff}) and electron densities (N_e) can be determined by using of these factors.

A parallel beam of monoenergetic photons passing through sample is attenuated due to absorption and scattering. Attenuation due to absorption follows the Beer-Lambert's rule,

$$\frac{I}{I_0} exp[-\mu t] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

here I/I_0 is the transmission factor or transmissivity (T), I_0 and I are the unattenuated and attenuated photon intensities, respectively, μ (cm^{-1}) is the linear attenuation coefficient of the sample and t thickness of sample.

MATERIALS AND METHODS

Experimental arrangement

The experimental setup is shown in Fig. 1. The intensity of Am-241 point source is 100 mCi. The spectra were obtained for a period of 1000 s.

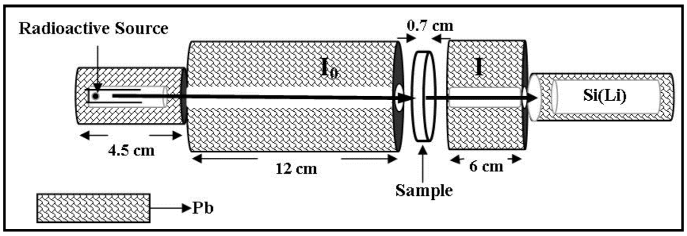

Fig. 1. The experimental setup

The net counts without absorber (I_0) and with absorber (I) were obtained at the same period and geometry. Representative spectrum of 59.5 keV γ-rays passed is shown Fig. 2.

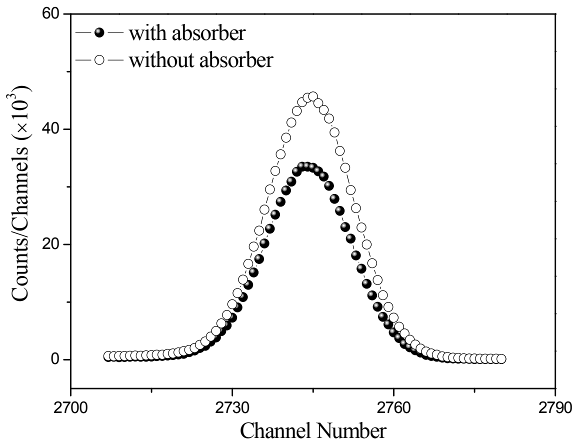

Fig. 2. A typical spectrum of 59.5 keV γ-rays passed through 50% fly ash and 50% borax mixture

Sample procedure

Slime and borax ore are taken from Kestelek Boron Company. Fly ash are taken thermal reactor established facility. These construction materials were grinded using mortar of agate hand. In addition to, these materials are sifted with 45 µm sieve to achieve a homogeneous distribution. Different ratios (0%, 25%, 50%, 75% and 100%) of borax and slime mixed together with various construction materials. After, these samples were mixed at 20 min by spex brand mixer. Cellulose ~0.1g was added for only fly ash. Mass of samples was measured by a very sensitive balance. The powder samples were compressed into pellets for 8 ton by using a manual hydraulic press. These samples had a diameter of 13 mm.

RESULTS AND DISCUSSION

At the present time, boron is increasing demand for its products and application areas. Consequently, countries with significant boron reserve have improved technology in order to ensure further economic income. Turkey comes at the beginning of these countries. Qualities of life of the countries have been improved due to contribution to economics of countries with mineral of boron. Boron is used in wide areas. At the same time, wastes of boron can be used in wide areas. Wastes of boron can be evaluated at the many different areas. If we use wastes of boron, we can evaluate many benefits such as storage costs and disappearance of problems, prevention of economic loss, failure to contamination of ground and surface water sources and environmental protection. In today, many studies have been done to be protected from the harmful effects of radiation because there are many natural and artificial sources of radiation in our environment namely; radon gas, cosmic rays, the radiation of interaction with matter of cosmic rays, medical X-rays, nuclear medicine, uranium and thorium series etc. These sources of radiation have affected the life and quality of life of organisms. Radiation sources have caused many diseases such as cancer. Accordingly, harmful effects of radiation should be prevented. In the present study, we purposed produce new construction materials from wastes of boron that these materials have attenuated radiation with certain energy.

The experimental transmission coefficients of samples have been measured by using energy dispersive X-ray fluorescence spectrometer (EDXRF) at 59.5 keV. We mixed with different ratio of borax and slime together with various construction material that tile adhesive, clay, satin plaster, black cement (strength of daily pressure = 32.5; 42.5 and 52.5 MPa), grouting and fly ash to use in the experiment.

To the best of our knowledge there are no experimental data reported in the literature for these samples at 59.5 keV γ-rays. The present result constituting the first experimentally. Chemical analyses of slime are listed in Table 1. Firstly, radioactivity of slime was determined by using Geiger-Müller meter and Si(Li) detector. According to results, slime hasn't radioactivity. Therefore, slime can be used in the life area of organisms.

Table 1. Chemical analyses of Slime

Parameters	Slime(%)
CaO	21.48
SiO_2	14.62
B_2O_3	14.55
Al_2O_3	7.66
MgO	6.22
Fe_2O_3	1.63
SO_4	0.64
SO_3	0.53
SrO	0.33
Na_2O	0.32
As(ppm)	106.82
As_2O_3(ppm)	141.00

Transmission factors have been plotted versus concentration of borax and slime and in Fig. 3-18 for grouting, tile adhesive, clay, satin plaster, black cement (strength of daily pressure = 32.5; 42.5 and 52.5 MPa) and fly ash. As seen in Fig 3-18, the experimental transmissivity results have been fitted. Deviation in some values can be emanated the problem of narrow beam in the experiment geometry, in homogeneous mixture and thickness of samples.

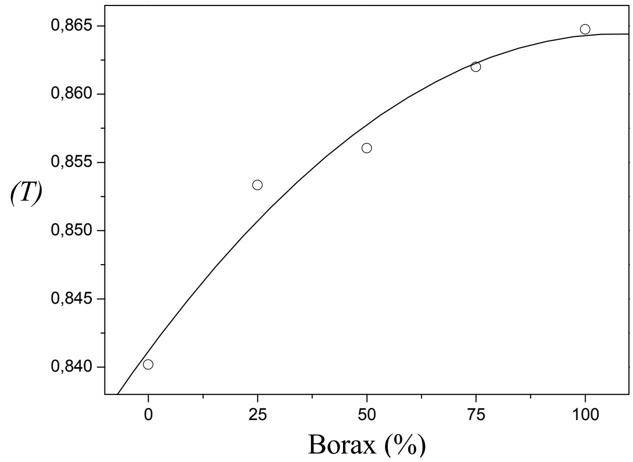

Fig. 3. Transmissivity versus concentration of borax for grouting mixed with borax

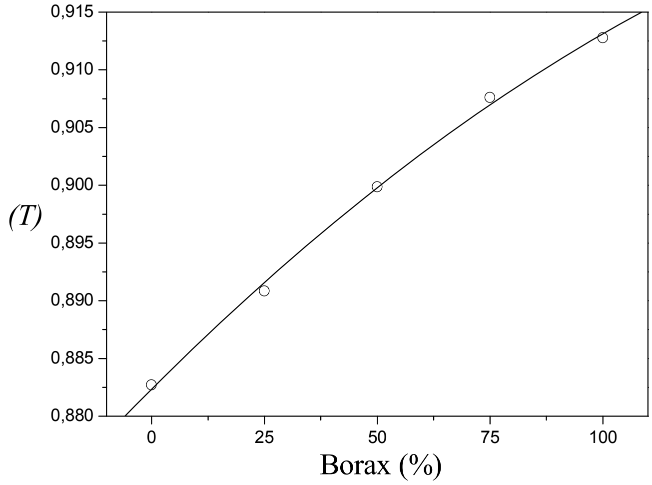

Fig. 4. Transmissivity versus concentration of borax for clay mixed with borax

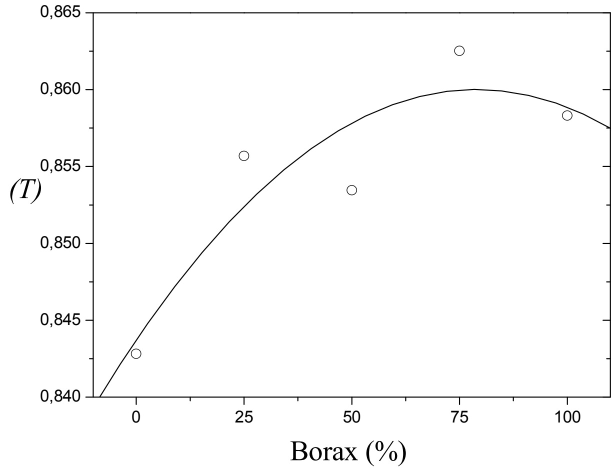

Fig. 5. Transmissivity versus concentration of borax for tile adhesive mixed with borax

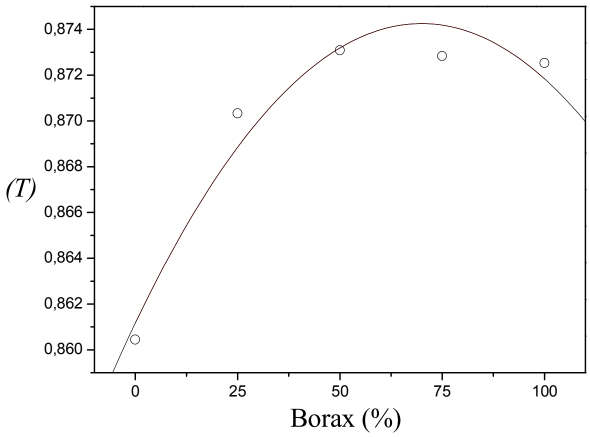

Fig. 6. Transmissivity versus concentration of borax for satin plaster mixed with borax

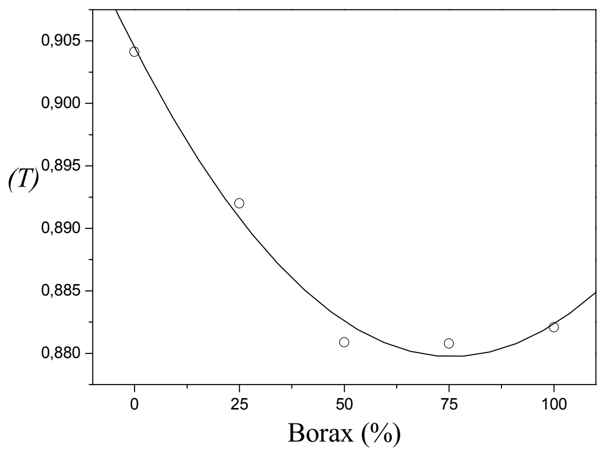

Fig. 7. Transmissivity versus concentration of borax for strength of daily pressure 32.5 MPa black cement mixed with borax

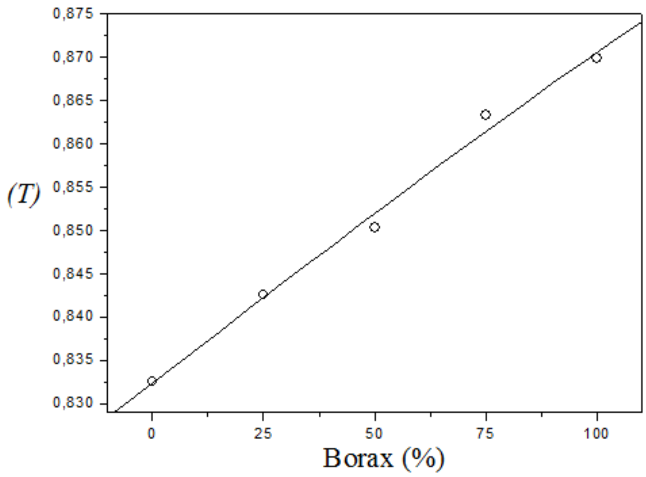

Fig. 8. Transmissivity versus concentration of borax for strength of daily pressure 42.5 MPa black cement mixed with borax

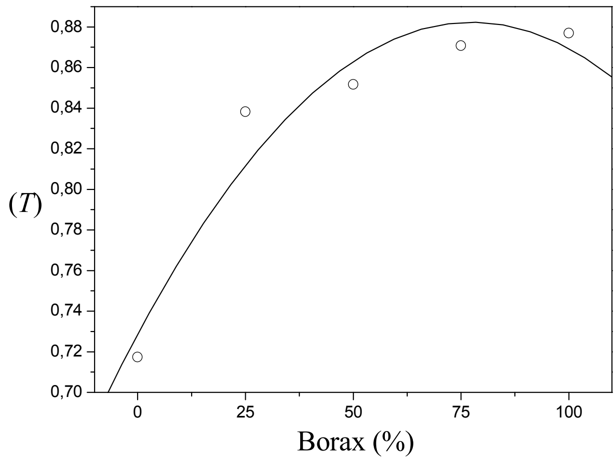

Fig. 9. Transmissivity versus concentration of borax for strength of daily pressure 42.5 MPa black cement mixed with borax

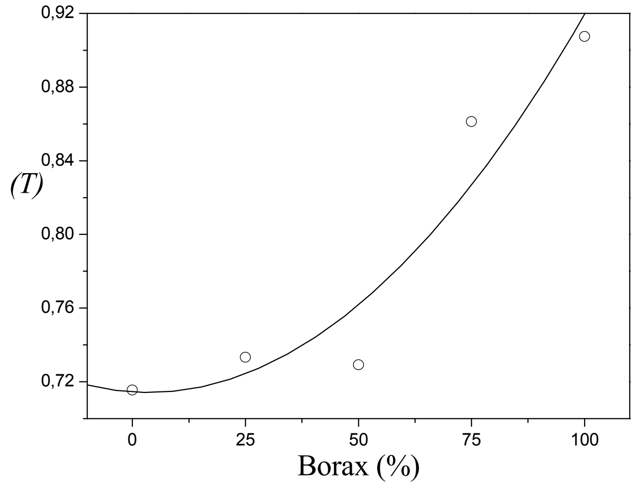

Fig. 10. Transmissivity versus concentration of borax for fly ash mixed with borax

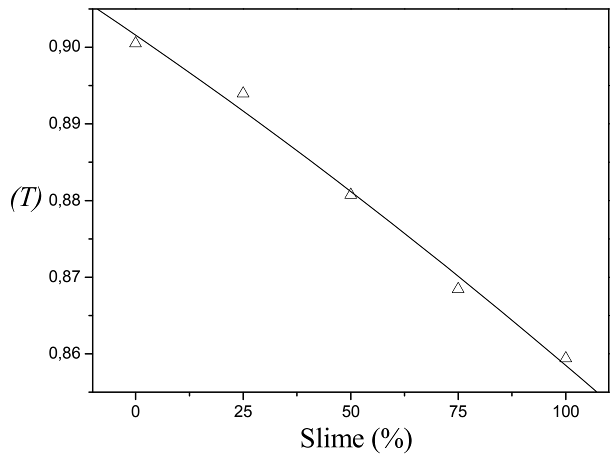

Fig. 11. Transmissivity versus concentration of slime for

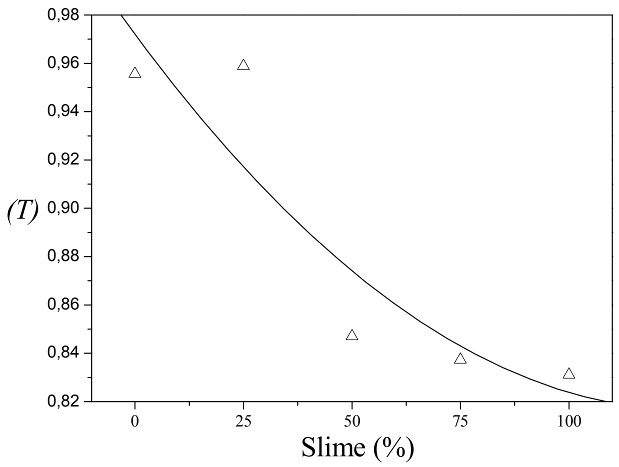

Fig. 12. Transmissivity versus concentration of slime for clay mixed with slime

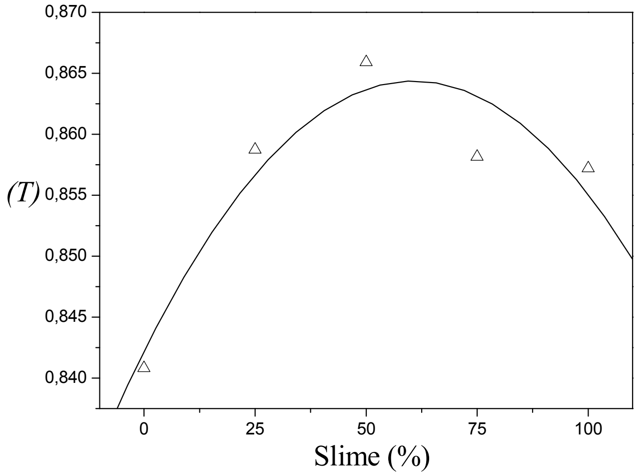

Fig. 13. Transmissivity versus concentration of slime for tile adhesive mixed with slime

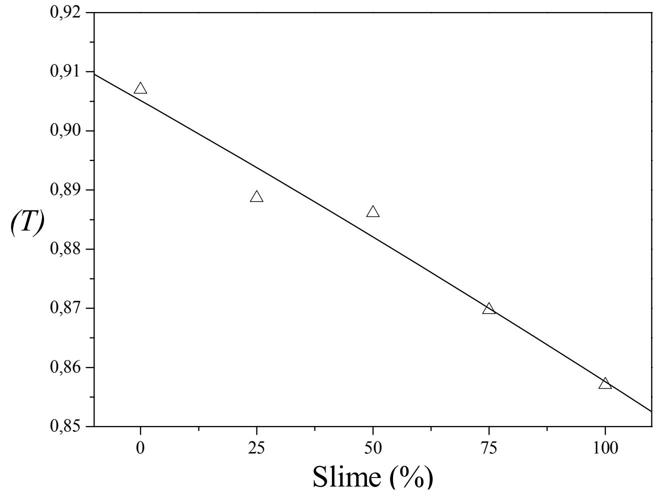

Fig 14. Transmissivity versus concentration of slime for satin plaster mixed with slime

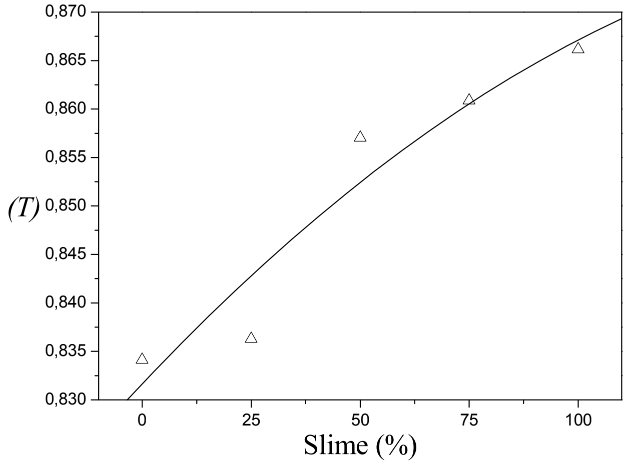

Fig. 15. Transmissivity versus concentration of slime for strength of daily pressure 32.5 MPa black cement mixed with slime

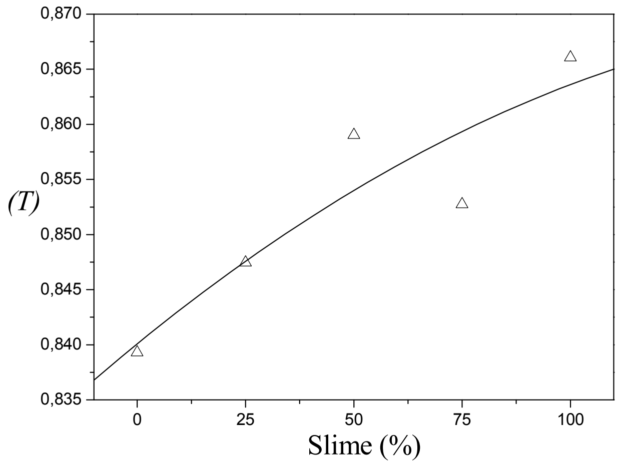

Fig. 16. Transmissivity versus concentration of slime for strength of daily pressure 52.5 MPa black cement mixed with slime

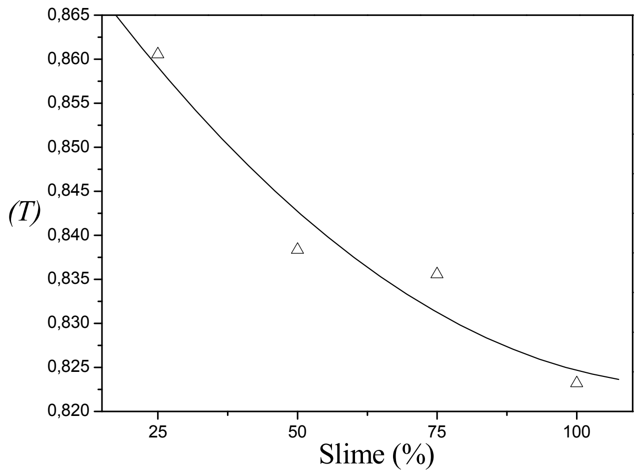

Fig. 17. Transmissivity versus concentration of slime for strength of daily pressure 42.5 MPa black cement mixed with slime

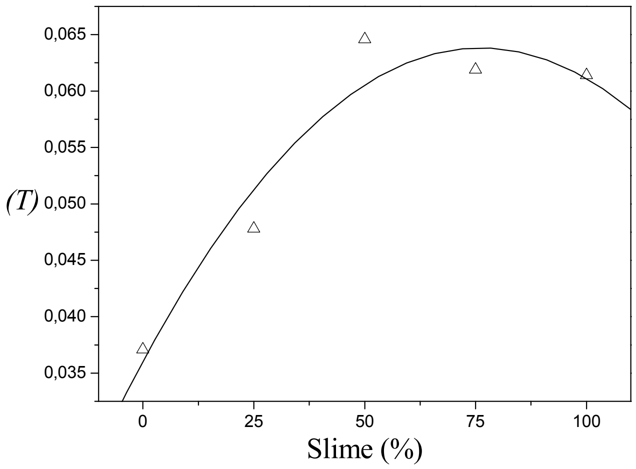

Fig. 18. Transmissivity versus concentration of slime for fly ash mixed with slime

In Fig 3; 4; 8; 9; 10; 15 and 16 the more concentration of slime and borax increase, the more transmissivity increase. As shown in Fig 5; 6; 13 and 18 the concentration of slime and borax increase, the transmissivity firstly increases and after decreases. As seen in Fig 7; 11; 12; 14 and 17 the more concentration of slime and borax increase the more transmissivity decrease. Generally, the samples with increased borax concentration become transparent than others. In Fig 11; 12; 14 and 17 transmission factors decrease with increased slime concentration. On the contrary, in this instance the samples with increased slime concentration become absorbent than others.

Conclusion

Construction materials mixed with slime can be used in the building, because these materials haven‘t radioactivity and the study, transparent properties of these samples introduce for different needs. However, this work encourages that different construction material to obtain in materials engineering. In the today, the isolation of heat and sound are important at the construction industry but “concept of the isolation of radiation” will be very important in the further. This work has supported this topic.

Further experimental studies on measurements of transmissivity should make for low, medium and high photons energy in the different region of electromagnetic spectrum and various construction materials.

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